



# Atmospheric dispersion modelling in support of civil emergency operations

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# Civil emergency operations

- General framework for handling risk:
  - Prior to any emergency:
    - Comprehensive assessment of risk;
    - Implementation of risk mitigation measures.
  - In the event of an emergency:
    - Trained capability for “timely intervention”.
- What does this framework mean in the case of civil emergencies involving the atmospheric dispersion of chemical or biological (CB) warfare agents?

# Atmospheric dispersion modelling

- Atmospheric dispersion is a complex process, involving:
  - **A variety of weather conditions;**
  - A variety of sources;
  - A variety of environments;
  - A variety of analytical methods;
  - A variety of impacts and responses.
- This complexity means that the operational response must be fundamentally expert-based.
  - However, the human capability can be usefully reinforced by the provision of appropriate computational tools.
  - Models are tools for the experts.

# Smoke plumes and stability classes

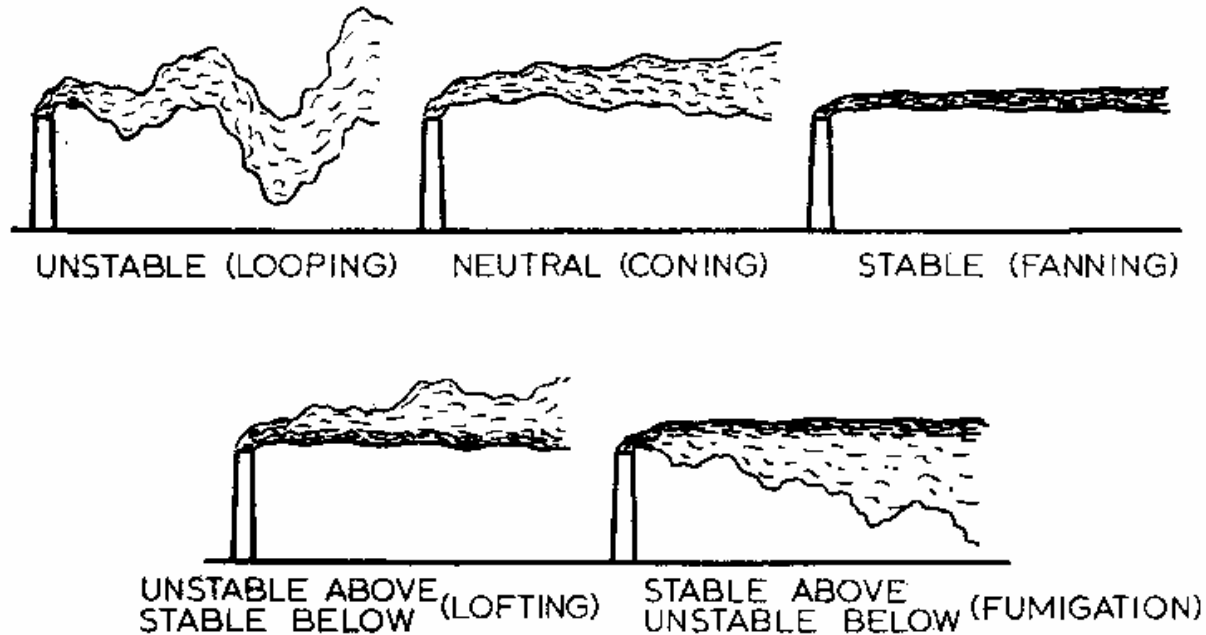
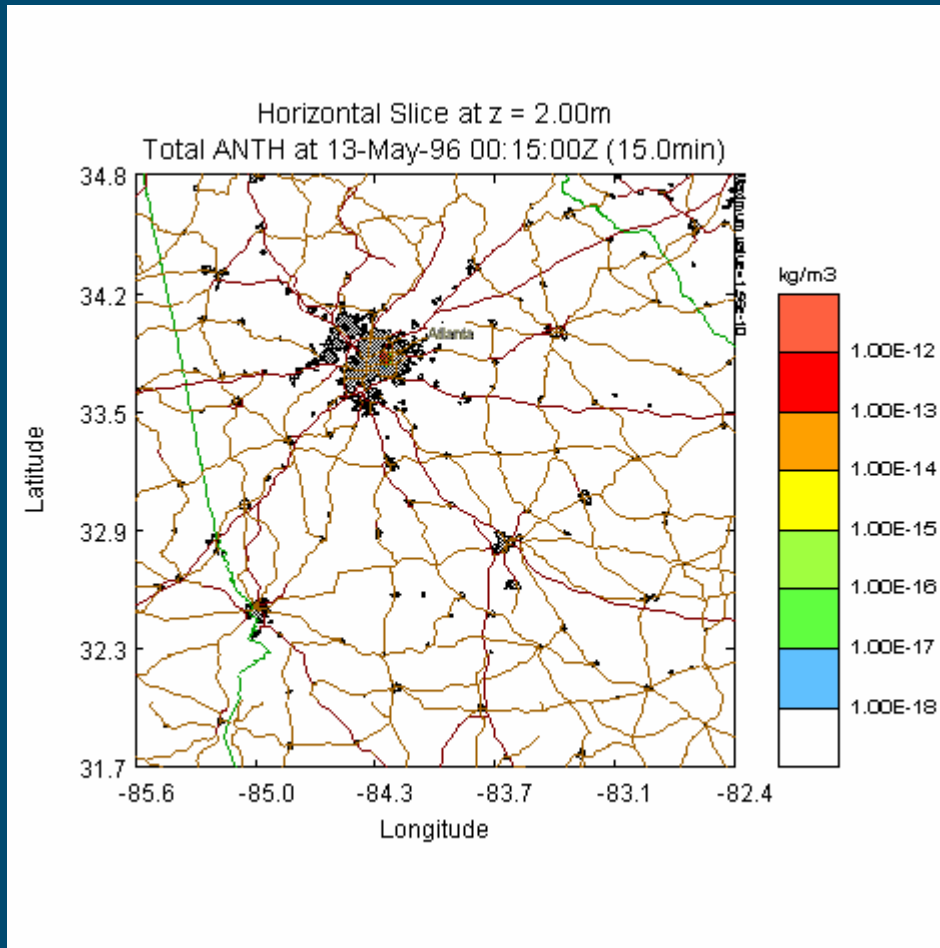


FIG. 5.2 Characteristic forms of smoke-plumes from chimneys. (Church, 1949, and United States Weather Bureau, 1955)

Ref: Frank Pasquill, *Atmospheric Diffusion*, van Nostrand (London, 1962)

# Effect of wind variation



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# The CBW spectrum illustrates the range of materials that could be used as CBW agents

<b>Toxic industrial chemicals (TICS)</b>	<b>Major CW agents</b>	<b>Emerging CW agents</b>	<b>Mid spectrum agents</b>	<b>BW agents</b>	<b>Genetically modified BW agents</b>
HCN Phosgene chlorine ammonia	vesicants nerve agents psycho-chemicals	developments from pharmaceutical & pesticide research	toxins bioregulators	bacteria rickettsia viruses	bacteria rickettsia viruses
<b>synthetic chemicals</b>			<b>agents of biological origin</b>		
				<b>self-replicating</b>	

increasing potency (up to  $\sim 10^{12}$ )



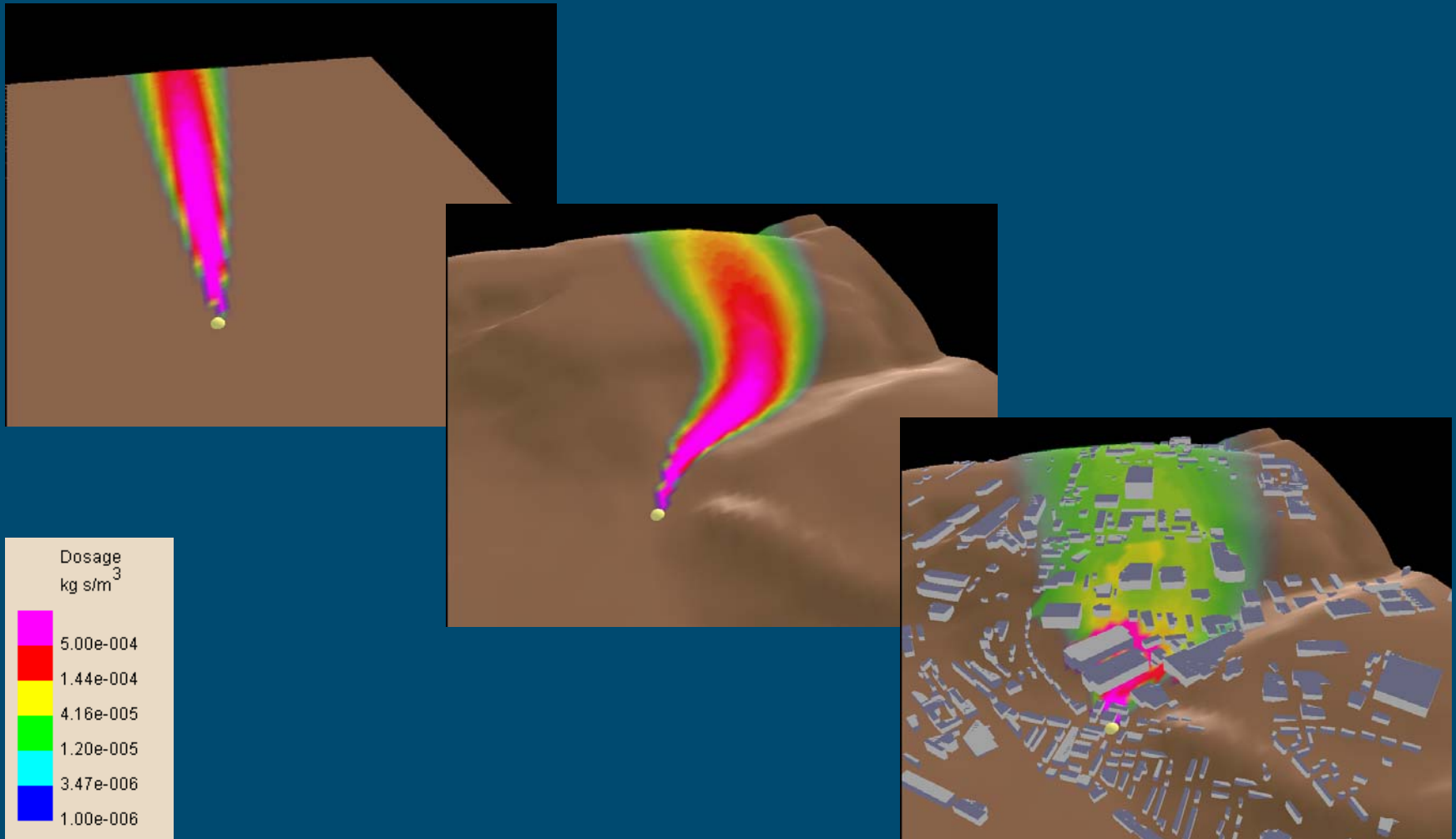
# CB hazard source terms

- Instantaneous or continuous; ground-level or elevated?
  - Point, line, area or volume source?
- Solid, liquid or gas; particulate, aerosol or vapour?
- Combusting, reacting, decaying, or inert?
- Heavier or lighter than air?
- Hotter or colder than air?
- Deposition, washout, resuspension?

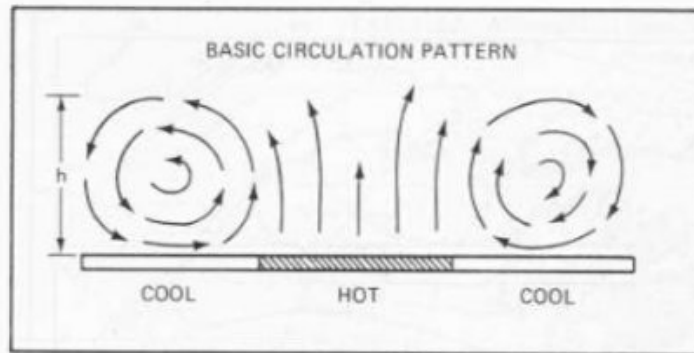
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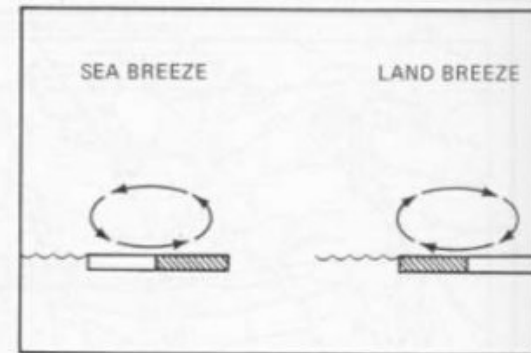
# Dispersion environments



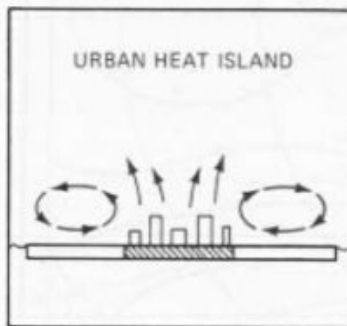
# Modification of dispersion: Mesoscale terrain effects



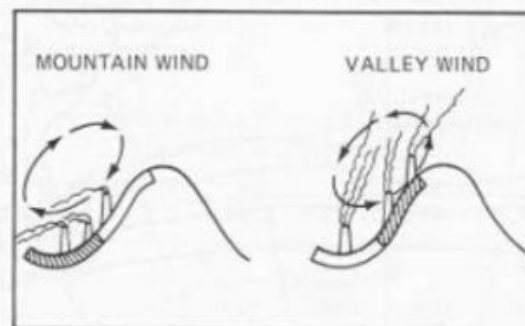
(a)



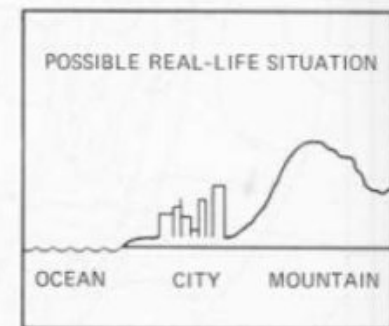
(b)



(c)



(d)



(e)

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# CB impacts

- Death, incapacitation, exposure or infection
  - Incapacitation: myosis, choking, vomiting, irritation, blistering, spasms, paralysis, disorientation, hallucination...
- Taking effect through the lungs, eyes, nose or skin
- Peak concentration or accumulated dose?

# UK policy areas for defence against use of CB agents

- Arms control
- Preventing supply
- Deterring against use
- Defending against use
  - Detection, identification and monitoring
  - Warning and reporting
  - Physical protection
  - Hazard management
  - Medical countermeasures and support



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# Current implementation

- Operational modelling support to major events:
  - 2000 Sydney Olympics;
  - 2001 US Presidential Inauguration;
  - 2002 Salt Lake City Winter Olympics.
  - 2004 Athens Olympics - Dstl Tools Used
- During emergency

# System Approach to Hazard Modelling

- Modelling and Simulation approaches could be used to support civil emergency applications.
- Dstl have produced a CB synthetic environment
  - has been used in military experimentation
- a CB event is the same for civil as well as military
- Could stimulate civil response systems
  - testing of civil response systems
  - emergency planning

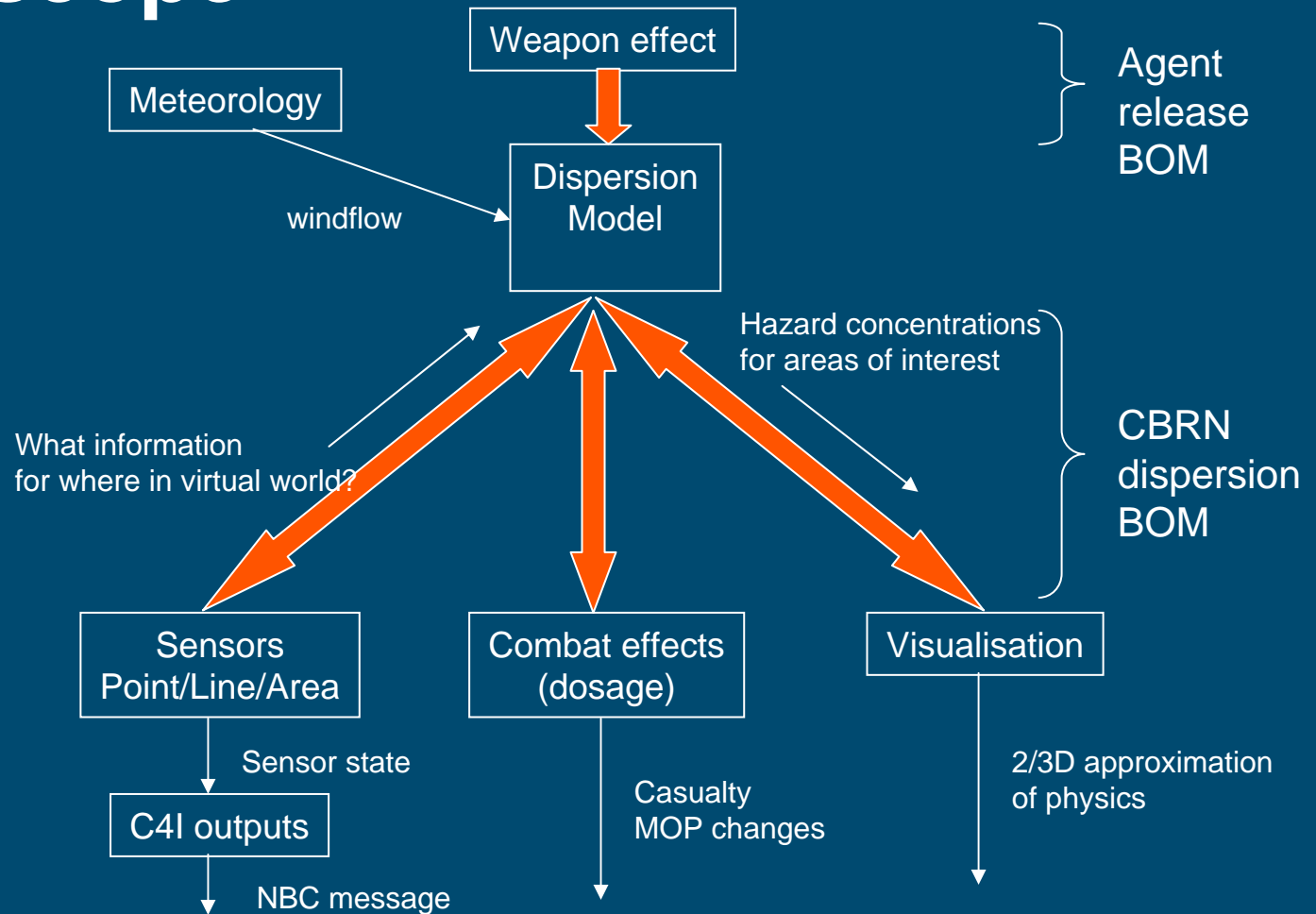
# Aims for HLA hazard modelling

- Support physics-based or simplistic source/sensor models
  - concisely handle simple/complicated sensor requests
- Protocols suited to variety of input/dispersion model
- Enormous complexity in atmospheric dispersion
  - Each simulation could use range of different representations - finite difference, finite element, gaussian puff etc.
- Sensors should not need to know complete ground-truth
  - could trigger on variety of agents/particle sizes etc.

# Approach to HLA representation

- Uses BOMs
  - WMD hazards are not studied in isolation
- Two separate BOM sets dealing with
  - the releases of agents
  - transportation of hazard to:
    - sensors and detectors
    - other affected simulated entities
  - visualisation of the hazard
- How can we define the best representation in the BOMs?

# BOM scope



# BOM design

- How does the hazard get distributed by HLA
  - a) the whole environment gets published (like wind)
  - b) the sensor registers its interest & gets a subset
- We chose b) because
  - the size of the environment versus number of sensors
  - dramatically reduces network bandwidth
  - not tied to an inappropriate network representation

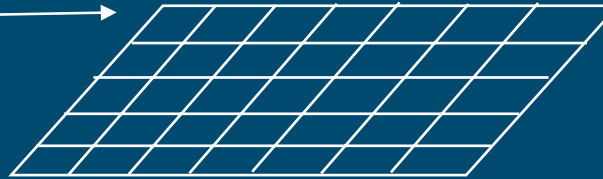
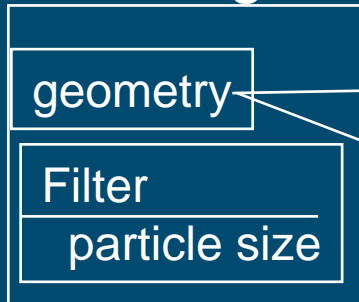


# Outline of the BOMs

- Spatial classes
  - point, linear and area (grid) values
- Filter object
  - allows sensor to describe its interest in different ways
    - by type
    - by particle size
    - by radioactivity
  - specifying filters allows the dispersion model to combine values and thereby reduce bandwidth

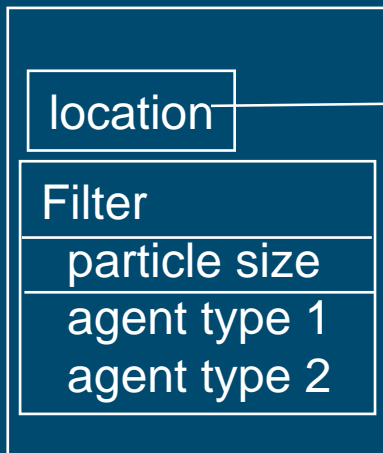
# Using the Sensor object BOM

## CBRN grid

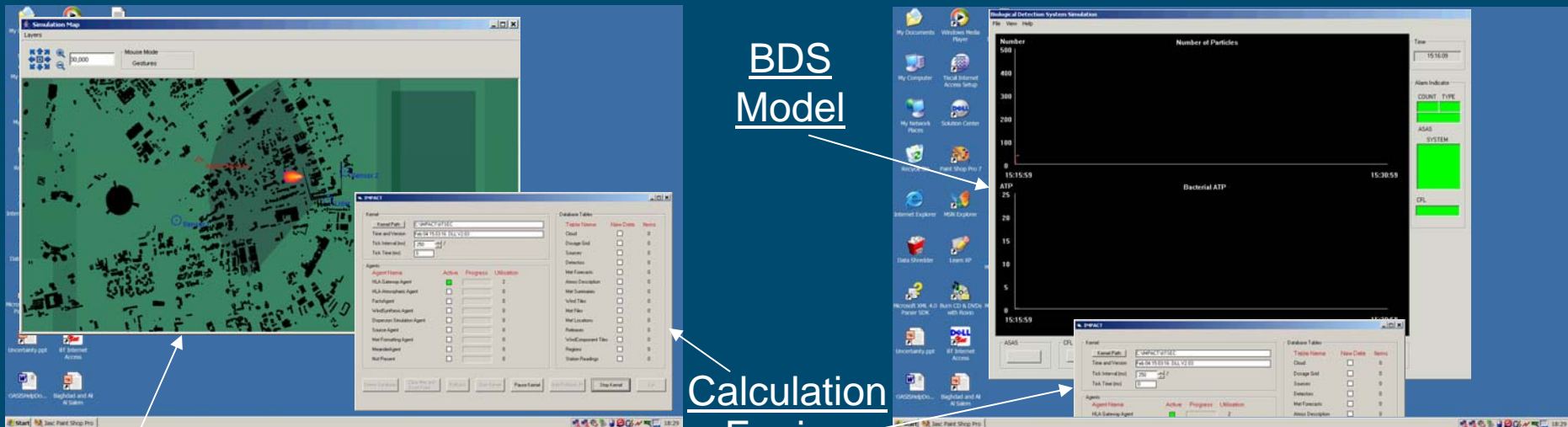


Density at  
each grid point

## CBRN point



density of particles in size  
range  
density of agent 1  
density of agent 2  
...

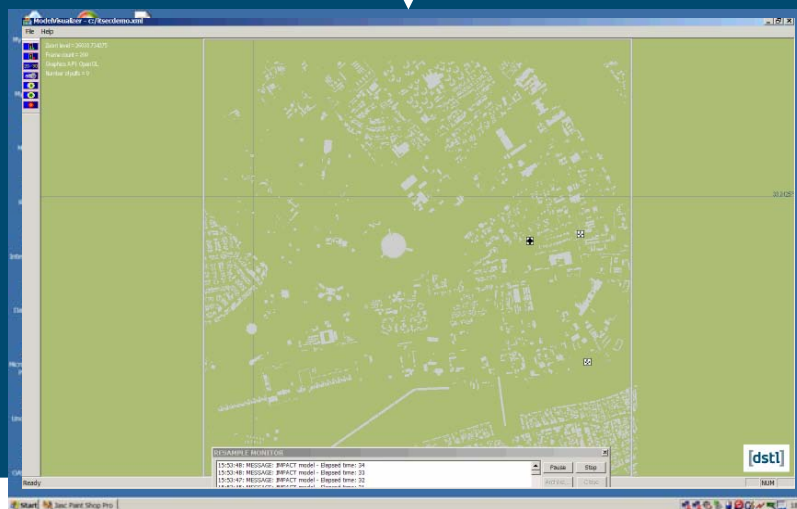


Lidar Model

Network (HLA RTI)



DTRA's WALS  
3<sup>rd</sup> party chem  
sensor models



GUI



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